Mathematics of Computation

Coden: MCMPAF

Volume 27, Number 122

Pages 221-453

April 1973

Editorial Committee

EUGENE ISAACSON, Chairman, New York University, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, New York 10012
Assistant to the Chairman: CHARLOTTE W. JOHN

James H. Bramble, Department of Mathematics, Cornell University, Ithaca, New York 14850

ALSTON S. HOUSEHOLDER, Department of Mathematics, Ayres Hall, The University of Tennessee, Knoxville, Tennessee 37916

John W. Wrench, Jr., Naval Ship Research and Development Center, Bethesda, Maryland 20034

Board of Associate Editors

James W. Daniel, Department of Mathematics, University of Texas at Austin, Austin, Texas 78712

Walter Gautschi, Computer Sciences Department, Purdue University, Lafayette, Indiana 47907

HEINZ-OTTO KREISS, Computer Science Department, University of Uppsala, Uppsala, Sturegaten 4, Sweden

YUDELL L. LUKE, Department of Mathematics, University of Missouri at Kansas City, Kansas City, Missouri 64110

James N. Lyness, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439

Beresford Parlett, Department of Computer Science, University of California, Berkeley, California 94720

PHILIP RABINOWITZ, Department of Applied Mathematics, The Weizmann Institute of Science, Rehovot, Israel

JOHN R. RICE, Division of Mathematical Sciences, Purdue University, Lafayette, Indiana 47907

Daniel Shanks, Naval Ship Research and Development Center, Bethesda, Maryland 20034

HANS J. STETTER, Institut für Numerische Mathematik, Technische Hochschule Wien, Karlsplatz 13, A-1040 Wien, Austria

Information for Subscribers

The journal is published quarterly in one volume per year, with issues numbered serially since Volume 1, Number 1. The subscription price is \$24.00. All back volumes are available. For Volumes 1–19 (1943–1965), prices are \$20.00 per volume; for Volumes 20–23 (1966–1969), \$24.00 per volume and Volumes 24–26 (1970–1972), \$30.00 per volume.

Unpublished Mathematical Tables

The editorial office of the journal maintains a repository of Unpublished Mathematical Tables (UMT). When a table is deposited in the UMT repository a brief summary of its contents is published in the section *Reviews and Descriptions of Tables and Books*. Upon request, the chairman of the editorial committee will supply copies of any table for a nominal cost per page.

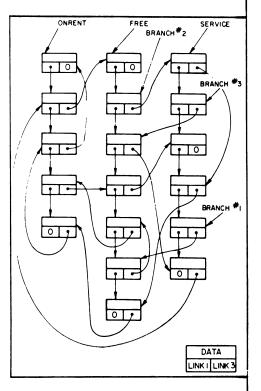
Subscriptions, address changes, business communications and payments should be sent to:

AMERICAN MATHEMATICAL SOCIETY
P. O. Box 6248
Providence, Rhode Island 02904

Take the mystery out of list processing with BRILLINGER and COHEN's-

Introduction to Data Structures and Non-Numeric Computation

(with WATFOR and WATFIV)

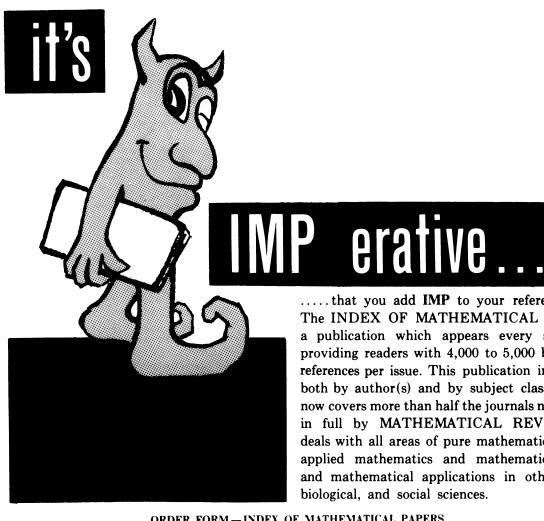


PETER C. BRILLINGER, University of Waterloo, and **DORON J. COHEN,** Technion-Israel Institute of Technology Computer Center.

A comprehensive discussion of data representations and data structures—this new book considers in detail operations and applications with character strings, linearly linked lists, graphs and trees. It offers an in-depth study of list processing techniques that teaches the basic algorithms usually used by high-level list processing languages. The authors explain programming language translation, including syntax analysis, object-code generation, and macro processors. Introduction to Data Structures and Non-Numeric Computation (with WATFOR and WATFIV) explores details of real-life systems such as car rental transactions, symbolic manipulation of expressions, and organization of index terms for a book. Elaborate explanations and fully coded examples provide for self-study, and emphasis is placed on mechanics rather than theory. The authors stress method and internal representations rather than the language itself. The text provides ample problems, exercises, and illustrations of examples to facilitate learning.

1972 629 pp. 6 x 9 cloth (013-479899-6) \$12.00

Prentice-Hall, Englewood Cliffs, N. J. 07632



Period Covered

Volume and Issue

.....that you add IMP to your reference library. The INDEX OF MATHEMATICAL PAPERS is a publication which appears every six months, providing readers with 4,000 to 5,000 bibliographic references per issue. This publication indexes titles both by author(s) and by subject classification. It now covers more than half the journals now reviewed in full by MATHEMATICAL REVIEWS; and deals with all areas of pure mathematics; topics in applied mathematics and mathematical physics; and mathematical applications in other physical, biological, and social sciences.

Price per Copy

Quantity Ordered

Total Price

ORDER FORM-INDEX OF MATHEMATICAL PAPERS **Publication Date**

Volume 1	July – December 1970	July 1972	\$30		- \$
Volume 2, Issue 1	January –June 1971	November 1972	\$30		\$
Volume 2, Issue 2	July—December 1971	January 1973	\$30		\$ <u></u>
Volume 3, Issue 1	January→June 1972	April 1973	\$40		\$
Volume 3, Issue 2	July—December 1972	April 1973	\$40		\$
Payment enclosed \$			Date		
☐ Please bill					
☐ Please enter my	standing order forc	opy(ies), to begin with V	olume		
☐ Please send info	rmation on the magnetic ta	pe edition of the Index.			
Send bill to		Ship to)		



SIAM JOURNAL ON COMPUTING

began publication as a quarterly in March 1972. It contains research articles in mathematics that apply to the problems of computer science and the non-numerical aspects of computing.

TOPICS IN THIS JOURNAL INCLUDE:

- Automata, formal languages, analysis of algorithms, computational complexity, computational linguistics, and the theory of computer programming.
- Computational aspects of combinatorics and graph theory including enumeration, ordering, searching, and graph manipulation.
- Formal aspects of compilers, programming languages, semantics, symbol manipulations, artificial intelligence, information retrieval, data structures, operating systems, and computer architecture.

SIAM Journal on Computing contains research articles dealing with the mathematical and formal aspects of computer science and non-numerical computing. Many of the foundations of computer science are mathematical and derive from a wide spectrum of mathematical disciplines. The purpose of this journal is to provide a medium for the crossfertilization of mathematics and computer science that should benefit both the computing and mathematical communities and illuminate new areas for mathematical application.

MONTHS OF PUBLICATION

MARCH JUNE SEPTEMBER DECEMBER

MANAGING EDITOR

Dr. Philip M. Lewis II

General Electric Research and Development Center Schenectady, New York

EDITORS

Professor Arthur J. Bernstein, Computer Science Department, State University of New York.

Professor Henry D. Block, Department of Theoretical and Applied Mathematics, Cornell University.

Professor W. Morven Gentleman, Faculty of Mathematics, Department of Applied Analysis and Computer Science, University of Waterloo.

Dr. R. L. Graham. Bell Laboratories.

Professor Juris Hartmanis, Department of Computer Science, Cornell University.

Professor John E. Hopcroft, Computer Science Department, Cornell University.

Professor Richard Karp, Computer Science Department, University of California, Berkeley.

Professor Eugene Lawler, Department of Electrical Engineering and Computer Science, University of California, Berkeley.

Professor C. L. Liu, Department of Computer Science, University of Illinois.

Professor J. T. Schwartz, Courant Inst. of Math. Sciences, New York University.

Dr. Richard E. Stearns, General Electric Research and Development Center.

SEND ORDERS TO SIAM PUBLICATIONS 33 S. 17th Street, Phila., Pa. 19103

PLEASE NOTE:

All orders from Japan should be sent to our exclusive agent: U. S .- ASIATIC COMPANY, LTD., Tsutsumi Bldg. 13-121-chome, Shimbashi Minato-ku, Tokyo, Japan.

per volume (4 issues) add \$5.00 per volume for overseas orders.

SIAM Members: \$2400

Bounds on Iterated Coerror Functions and Their Ratios D. E. Amos	413
An Asymptotic Expansion of $W_{k,m}(z)$ with Large Variable and Parameters R. Wong	429
Reviews and Descriptions of Tables and Books	437
Table Errata Choong, Daykin & Rathbone 501, Erdélyi, Magnus, Oberhettinger & Tricomi 502, Gradshteyn & Ryzhik 503.	451
CORRIGENDUM KRAVITZ & MADACHY	453

Information for Contributors

Manuscripts should be typewritten double-spaced in the format used by the journal. For journal abbreviations, see the latest *Mathematical Reviews* volume index. An author should submit the original and one copy of the manuscript and retain one copy. The author may suggest an appropriate editor for his paper. It is recommended that the author acquaint himself with the pertinent material contained in "Information for Contributors to Mathematics of Computation" and "Manual for Authors," both of which are available upon request from the American Mathematical Society. All contributions intended for publication and all books for review should be addressed to Eugene Isaacson, Chairman, Editorial Committee, Mathematics of Computation, New York University, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, New York 10012. Institutions sponsoring research reported in the journal are assessed page and microfiche charges.

Each article submitted for publication must be accompanied by a brief and reasonably self-contained abstract, and by AMS (MOS) subject classification numbers. If a list of key words and phrases is included, it will be printed as a footnote on the first page. A list of the classification numbers may be found in the Index to Mathematical Reviews, Volume 39 (June 1970).

Microcard Edition

Volumes 1–14 (1943–1960) are available on Microcards at \$39.00 for the complete set and may be purchased from Microcard Editions, Inc., 901 26th Street, N. W., Washington, D.C. 20037.

Mathematics of Computation

TABLE OF CONTENTS APRIL 1973

The Finite Element Method with Penalty Ivo Babuška	221
Simplified Proofs of Error Estimates for the Least Squares Method for Dirichlet's Problem	229
On the Numerical Computation of Parabolic Problems for Preceding Times B. L. BUZBEE & ALFRED CARASSO	237
A Modified Butcher Formula for Integration of Stiff Systems of Ordinary Differential Equations	267
The Euler-Maclaurin Expansion for the Simplex J. N. Lyness & K. K. Puri	273
Asymptotic Expansions for Product Integration Frank de Hoog & Richard Weiss	295
Note on Error Bounds for Numerical Integration J. H. HETHERINGTON	307
On a Method of Carasso and Laurent for Constructing Interpolating Splines M. J. Munteanu & L. L. Schumaker	317
Chebyshev Approximation by Exponentials on Finite Subsets DIETRICH BRAESS	327
A Winding Number Algorithm for Closed Polygonal Paths J. V. Petty	333
Iteration Methods for Finding all Zeros of a Polynomial Simultaneously OLIVER ABERTH	339
On Computing Some Extremal Periodic Positive-Definite Functions R. L. PAGE	345
An Error Analysis of a Method for Solving Matrix Equations C. C. PAIGE	355
On Computing the Minimal Number of Defining Relations for Finite Groups T. W. Sag & J. W. Wamsley	361
An Algorithm for Generating the Sphere Coordinates in a Three-Dimensional Osculatory Packing	369
Calculation of the Ramanujan τ -Dirichlet Series Robert Spira	379
On the Vanishing of the Iwasawa Invariant μ_p for $p < 8000$ Wells Johnson	387
Three Thirteens L. J. Lander	397
On the Gaussian Primes on the Line $Im(X) = 1 \dots M$. C. WUNDERLICH	399
Complex Zeros of the Error Function and of the Complementary Error Function Henry E. Fettis, James C. Caslin & Kenneth R. Cramer	401
Saddle Point of the Complementary Error Function Henry E. Fettis, James C. Caslin & Kenneth R. Cramer	409